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Sensory perception in the hands of dentists

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EKENVALL L, NILSSON BY, FALCONER C. Sensory perception in the hands of dentists. *Scand J Work Environ Health* 1990;16:334-9. The difference between the dominant and nondominant hands in the perception of vibration, temperature, and heat pain was compared between 26 dentists with long-term exposure to high-frequency vibration and 18 with short-term exposure. The dentists with long-term exposure had larger vibration threshold differences than those with short-term exposure, both for digit II (exposed to high-frequency vibration) and for digit V (unexposed), whereas the temperature and pain thresholds were similar. The former group had neurological symptoms in the dominant hand more often than the latter. Vibration threshold differences of exposed digit II and unexposed digit V were higher for the symptomatic dentists than for the symptom-free dentists. Since the exposed and unexposed fingers were similarly affected, the neurological symptoms in the dominant hand of dentists with long-term exposure seem to have some other etiology than high-frequency vibration.

Key terms: high-frequency vibration, neurological symptoms, temperature thresholds, vibration thresholds.

It is not known whether high-frequency vibration from, for example, high-speed rotating handpieces or ultrasound devices used in modern dentistry can cause symptoms similar to those of the hand-arm vibration syndrome. Dentists were recently shown to have a higher frequency of neurological symptoms in their hands than pharmacists (1). In one study, dentists were found to have a slightly higher perception threshold for vibration in their dominant hand, which is exposed to high-frequency vibration, than in their unexposed nondominant hand, whereas no such difference existed in unexposed referents (2).

The present study was performed to evaluate further the possibility of nerve injury in the fingers of dentists. Sensitivity for vibration, temperature, and pain was studied in the dominant and nondominant hands of a group of dentists with many years of exposure to high-frequency vibration and a reference group with few years' exposure. The latter group was selected so that the "exposed" group and "reference" group would be as similar as possible.

Subjects and methods

Twenty-six dentists (18 men and 8 women) with at least 10 years in clinical dentistry and 19 (7 men and 12 women) with less than five years' experience agreed to participate in the study. Vibration thresholds are strongly age-dependent (3) but similar in the dominant

and nondominant hands of healthy referents (2, 4). To eliminate any influence from age in the comparison of the two groups, we used the threshold difference between the dominant and nondominant hands in the analysis. This type of comparison was used on the presumption that any normal aging processes diminishing sensory perception in the fingers should affect the dominant and nondominant hands similarly, whereas any effect of high-frequency vibration should be limited to the first three fingers of the dominant hand, since these three fingers are used for gripping the handpieces.

The protocol was approved by the local ethics committee. Initially four dentists with long-term exposure were examined before and after a workday so that we could determine whether any possible temporary threshold shift occurs during the day because of exposure to vibration (5). The results of the first examination of these dentists were used in the analysis.

The examinations were performed in a room with a temperature of $23 \pm 1^\circ\text{C}$. Skin temperature was measured at the palmar surface of the fingers before the perception tests were started. The temperature was usually between 31 and 34°C , and there was no systematic difference between the hands.

The mean ages of the dentists and their mean numbers of years in clinical work are shown in table 1. The

Table 1. Age and duration of clinical practice of the dentists with long-term exposure to high-frequency vibration and those with short-term exposure.

Exposure	N	Age (years)		Duration of clinical practice (years)	
		Mean	SD	Mean	SD
Long-term	26	50.0	6.6	24.5	6.8
Short-term	18	28.1	2.8	1.9	1.3

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daily exposure to rotating handpieces or ultrasound devices was difficult to estimate since the instruments were used often but briefly. No dentist had any significant leisure-time exposure to vibrating tools, and none had any disease with a possible relation to neuropathy. Four dentists with long-term exposure and one dentist with short-term exposure were smokers.

Vibration thresholds

The perception thresholds to vibration of 100 Hz was determined at the fingertips according to the method of Goldberg & Lindblom (3). A handheld vibrator (Vibrometer, Somedic AB) with a 13-mm diameter probe was placed on the skin of the palmar surface of the second and the fifth fingertips. The static pressure against the finger pulp corresponded to a weight of 600 g. The dorsal surface of the hand rested on a semisoft rubber board. The vibration amplitude was increased and decreased (0.7 dB/s) several times, and the vibration threshold was defined as the mean of the points (micrometers from peak to peak) where the vibration perception appeared and disappeared, respectively.

Vibrogram

A second method was used to investigate the perception thresholds at seven different vibration frequencies (8, 16, 31.5, 63, 125, 250, and 500 Hz). A test instrument based on a modified audiometer (Vibrometer 9589, Brüel & Kjaer) was used according to Lundborg et al (6, 7). The pulp of the second finger rested on the top of the vibration probe (diameter 13 mm) protruding through an opening in the test table. The stimulation frequency was automatically shifted in a stepwise manner from 8 to 500 Hz. The vibration amplitude changed continuously at 5 dB/s, an increase reverting to a decrease and vice versa when the subject indicated that the vibration perception came and disappeared, respectively. The graphic representation of the vibration amplitude (decibels relative to $1 \mu\text{m/s}^2$) at different frequencies constituted the vibrogram. The threshold at each frequency was taken as the mean between the peaks and troughs in the vibrogram.

Temperature sensation

The thresholds for the perception of warmth and cold at the fingertips were determined with a thermostimulator (Thermotest, Somedic AB) described by Fruhstorfer et al (8). The pulp of the second and fifth fingers, respectively, was placed on the surface of the thermode (16×24 mm), the temperature of which was suddenly changed (1°C/s) from a neutral base line of 32°C towards higher or lower temperatures. The subject indicated the first perception of warmth or of cold by pressing a button. The stimulus was repeated five times, and the threshold was taken as the mean

of the three most similar values. The neutral zone was defined as the difference between the warm and cold perception levels.

Heat pain

The same thermode was heated up to the point where the warm sensation changed to pain. The stimulus was repeated three times in each of the investigated areas on the tips of the second and fifth fingers, and the median value was taken as the heat pain threshold.

Statistical methods

We used the difference between the dominant and non-dominant hands when we compared the two groups of dentists and calculated 95 % confidence intervals for the mean differences with the t-distribution (unequal standard deviations were presumed for the variables). Fisher's exact test with a confidence limit of 0.05 was used when we compared the symptom frequencies.

Results

One dentist with short-term exposure was excluded from the study on the suspicion of a technical fault. One dentist with short-term and nine with long-term exposure complained of neurological symptoms from the dominant hand ($P=0.03$). Seven, including the dentist with short-term exposure, had symptoms exclusively localized to the dominant hand, and three had bilateral symptoms. None had symptoms in the non-dominant hand only. The symptom descriptions included tingling, numbness or reduced sensibility, and reduced manipulative dexterity, and the symptoms could, in most cases, not be localized exclusively to median or ulnar innervated skin areas. Four dentists with long-term exposure but none of those with short-term exposure had Raynaud's phenomenon, all bilaterally. One dentist with short-term exposure and 16 with long-term exposure had musculoskeletal symptoms in the neck and upper extremities ($P=0.0001$).

There were no differences in the results obtained in the morning before exposure and in the afternoon after exposure in any tests of the four dentists who were examined twice.

Vibration threshold

The dentists with long-term exposure had higher vibration thresholds in the dominant hand than in the non-dominant hand at 100 Hz for both the second [mean difference $0.73 \mu\text{m}$, 95 % confidence interval (95 % CI) $0.01-1.46 \mu\text{m}$] and the fifth (mean difference between hands $1.35 \mu\text{m}$, 95 % CI $0.17-2.53 \mu\text{m}$) fingers. The dentists with short-term exposure showed no such difference for either finger (mean difference on the sec-

Figure 1. Vibration thresholds (mean, μm from peak to peak) at 100 Hz of the second and fifth fingers of the dominant (D) and nondominant (ND) hands of the dentists with long-term and those with short-term exposure.

Figure 2. Vibrogram (mean, dB relative to $1 \mu\text{m/s}^2$) from the second finger of the hands of the dentists with long-term and those with short-term exposure.

ond finger $-0.08 \mu\text{m}$, and on the fifth $0.12 \mu\text{m}$). The thresholds are shown in figure 1.

The dentists who had neurological symptoms in the dominant hand and had had long-term exposure had greater differences between their hands than those who had no symptoms (0.92 versus $0.64 \mu\text{m}$ for the second finger and 2.57 versus $0.70 \mu\text{m}$ for the fifth). This difference was not significant in this small material. The difference between hands was greater for the dentists with long-term exposure but without symptoms than for the dentists with short-term exposure for the second (mean $0.71 \mu\text{m}$, 95 % CI $0.05-1.37 \mu\text{m}$) but not for the fifth (mean $0.58 \mu\text{m}$, 95 % CI $-0.54-1.70 \mu\text{m}$) finger.

Vibrogram

The perception thresholds for vibration with a frequency of 8–500 Hz are shown in figure 2. There was a positive difference between the dominant and nondominant hands at all frequencies among the dentists with long-term exposure, significant however only at 8, 16, and 500 Hz. Among the dentists with short-term exposure the difference was sometimes positive and sometimes negative, and at no frequency was the difference statistically different from zero. The older dentists with long-term exposure had a greater difference between their hands than the dentists with short-term exposure only at 8 and 16 Hz, but there was a tendency also at 32 and 63 Hz.

When the dentists with long-term exposure but without symptoms were compared with the dentists with short-term exposure, all the significant differences between the groups disappeared (table 2). The dentists with long-term exposure and symptoms in the dominant hand had a greater difference between their hands at 8 and 16 Hz than the dentists with long-term exposure but no symptoms (at 8 Hz 5.11 and 0.67 dB, respectively, 95 % CI 1.02—7.87, at 16 Hz 6.11 and 2.35 dB, respectively, 95 % CI 0.64—6.88).

Temperature and heat pain thresholds

For both hands the dentists with long-term exposure had wider neutral zones in the second and fifth fingers than the dentists with short-term exposure, and the difference between the dominant and nondominant hands was similar in both groups. The dentists with long-term exposure and symptoms had neutral zones that were similar to those of the dentists without symptoms. The pain thresholds for heat in both hands and fingers were similar in the two groups of dentists with long- and short-term exposure, and also among the symptomatic and symptom-free dentists with long-term exposure. The results are shown in figure 3.

Discussion

In the present study dentists with long-term exposure had a high frequency of neurological symptoms in their hands, especially the dominant one. This finding is in accordance with the results obtained in an earlier epidemiologic survey (1). The symptom descriptions

were, in most cases, similar to those given by workers using traditional handheld vibrating tools. In the hand-arm vibration syndrome, temperature sensitivity is first reduced (9, 10). Defect vibration sensitivity is a later finding in patients with more advanced symptoms (10). These clinical findings have been reproduced in animal studies in which small nerve fibers have been shown to degenerate first in response to local vibration, large myelinated fibers being more resistant and needing longer vibration exposure to demonstrate degenerative changes (11). In the present study, dentists with long-term exposure to rotating handpieces had temperature threshold differences between their dominant and nondominant hands that were similar to

Table 2. Difference in the mean perception threshold between the second fingers of the dominant and nondominant hands of the symptom-free dentists with long-term exposure and the dentists with short-term exposure. Mean perception threshold and its standard deviation (dB relative 1 $\mu\text{m/s}^2$) and the 95 % confidence interval (95 % CI) for the difference between the two groups.

Level of vibration	Dentists with long-term exposure		Dentists with short-term exposure		95 % CI
	Mean	SD	Mean	SD	
8 Hz	0.7	5.2	-1.1	4.2	-1.7—5.1
16 Hz	2.4	4.8	0.0	5.4	-1.1—5.9
31.5 Hz	1.4	4.2	-1.2	6.5	-1.2—6.4
63 Hz	0.5	6.5	-2.3	5.2	-1.3—6.9
125 Hz	0.4	3.6	0.2	5.4	-2.9—3.5
250 Hz	-0.2	5.8	1.6	5.5	-5.7—2.1
500 Hz	4.1	8.7	2.1	5.6	-3.5—7.4

Figure 3. Temperature sensitivity (neutral zones) and heat pain thresholds of the dentists with long-term and those with short-term exposure. Mean values (°C) for the dominant (D) and nondominant (ND) hands.

those of dentists with short-term exposure. The dentists with neurological symptoms had thresholds similar to those of dentists without symptoms. The results indicate, even if the number of symptomatic dentists was small, that injury to thin nerve fibers is not the dominant finding in dentists as it seems to be in patients with hand-arm vibration syndrome. The finding of similar heat pain thresholds in the two groups of dentists also indicates that thin nerve fibers are not injured by high-speed rotating handpieces. Heat pain sensitivity is reduced in patients with the hand-arm vibration syndrome (12).

Dentists hold high-speed rotating handpieces with a grip involving only the first three fingers of the dominant hand. Vibration with a frequency of more than 1000 Hz is generated from these handpieces (13). Vibration at frequencies above 150–200 Hz tends to be isolated to areas of the hands and fingers directly in contact with the vibrating tool (14), and any adverse effect of high-frequency vibration should be limited to the structures in direct contact with the instruments. Thus, there is hardly any possibility that they can be transmitted through the hand of the dentist or through the oral tissues of the treated patient from the three first fingers to the fifth. In the present study, the difference in the vibration threshold at 100 Hz was increased between both the second and the fifth fingers of the dominant and nondominant hands. This finding makes high-frequency vibration an unlikely cause of the increased vibration thresholds on the dominant side, at least with respect to the fifth finger.

In the present study, only for the second finger did dentists with long-term exposure but no symptoms have a greater difference in the vibration threshold between hands at 100 Hz than the dentists with short-term exposure. The clinical relevance of this finding is doubtful, since the symptomatic dentists had values for their fifth finger that were at least as abnormal as those for the second finger. If the increased vibration thresholds of the second finger on the dominant side of the asymptomatic dentists were an early sign of vibration-induced injury, one would have expected the symptomatic dentists to have had an even greater difference in the thresholds of this finger. However, the dentists with symptoms were too few in this material for us to draw any valid conclusion from the outcome of the sensory testing.

The vibrogram gave information on the perception thresholds for vibration with frequencies between 8 and 500 Hz. At low frequencies, the Pacinian corpuscles are relatively insensitive, and other mechanoreceptors stimulated by static and low-frequency skin displacements are involved in the perception. Only in this low-frequency area, did the dentists with long-term exposure in the present study have greater differences between their hands than the dentists with short-term exposure. In the hand-arm vibration syndrome, sensibility for vibration with a frequency of 125–250 Hz, where the Pacinian corpuscles are the most sensitive,

is first reduced (7). Thus the slightly increased difference, at low frequencies, between the hands of the dentists with long-term exposure when they were compared with the dentists with short-term exposure, may be a work-related sensitivity disturbance, but, again, it seems unlikely that it is an early sign of the hand-arm vibration syndrome. This difference disappeared completely when only asymptomatic dentists were taken into account. Presumably the neurological symptoms in the dominant hand are in some way coupled to this finding. Since the vibrogram was performed only on the second fingers, we do not know whether the pathological touch sensitivity was limited to the median area or whether the same disturbance existed for the fifth finger.

In conclusion, dentists exposed to high-speed rotating handpieces for many years have a high frequency of neurological symptoms, especially in the dominant hand. The symptoms are comparable to those described in the hand-arm vibration syndrome. Our findings indicate that the neurological symptoms of the dentists have some other pathogenic background than the corresponding symptoms in workers exposed to traditional vibrating tools. The symptoms are presumably not caused by high-frequency vibration since the exposed second and the unexposed fifth fingers seemed to be similarly affected. Paresthesia in the hands has a multifactorial background. Carpal tunnel syndrome, other nerve entrapments, or cervical rhizopathy are common causes. Repetitive hand grips demanding high precision with the elbows bent, the shoulders often abducted, and the cervical spine flexed and rotated characterize dentist's work. Carpal tunnel syndrome is overrepresented in occupational groups with repetitive hand movements (15). Ulnar entrapment at the elbow is said to be common in people working with repetitive elbow movements (16). Dentists have a high frequency of neck and shoulder symptoms (17) and a high prevalence of cervical spondylosis (18). Thus there are many possible etiologies for the increased frequency of neurological symptoms in dentists with many years in the profession.

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